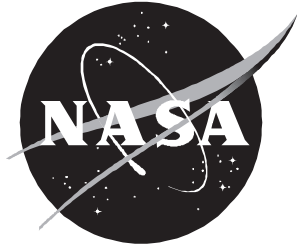


NASA/CR-1999-209118



# Aviation System Analysis Capability Executive Assistant Analyses

*Eileen Roberts and Peter Kostiuk  
Logistics Management Institute, McLean, Virginia*

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March 1999

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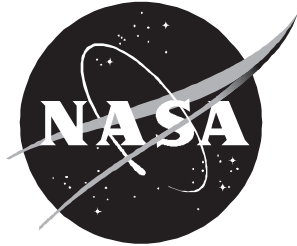
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# Aviation System Analysis Capability Executive Assistant Analyses

*Eileen Roberts and Peter Kostiuk  
Logistics Management Institute, McLean, Virginia*

National Aeronautics and  
Space Administration

Langley Research Center  
Hampton, Virginia 23681-2199

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# Chapter 1

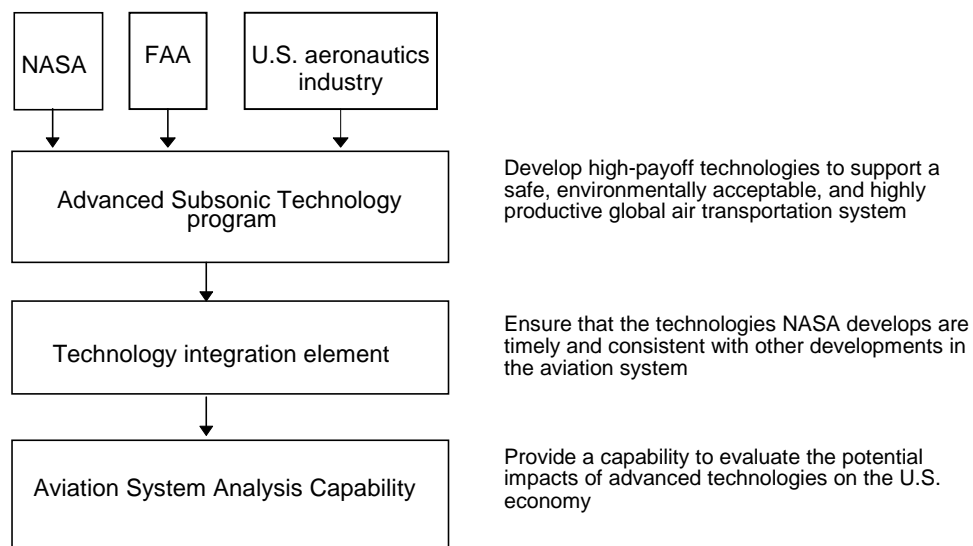
## Introduction

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### NASA'S RESEARCH OBJECTIVE

To meet its objective of assisting the U.S. aviation industry with the technological challenges of the future, NASA aims to identify research areas that have the greatest potential for improving the operation of the air transportation system. Therefore, NASA seeks to develop the ability of evaluating the potential impact of various advanced technologies. By thoroughly understanding the economic impact of advanced aviation technologies and by evaluating the use of new technologies in the integrated aviation system, NASA aims to balance its aeronautical research program and help speed the introduction of high-leverage technologies. Figure Chapter 1 -1 illustrates NASA's research objective.

*Figure Chapter 1 -1. NASA's Research Objective*



### GENESIS OF THE AVIATION SYSTEM ANALYSIS CAPABILITY

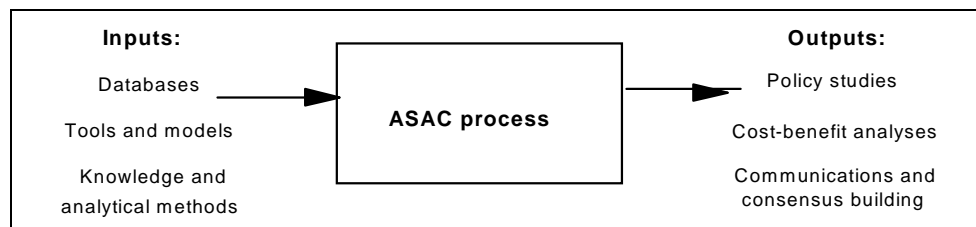
Technology integration is the element of the AST program designed to ensure that the technologies NASA develops are timely and consistent with other developments in the aviation system. Developing an Aviation System Analysis Capability (ASAC) is one of the objectives for integrating technology. With this analytical

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capability, NASA and other organizations in the aviation community can better evaluate the potential economic impacts of advanced technologies.

ASAC is envisioned primarily as a tool for understanding and evaluating the impacts of advanced aviation technologies on the U.S. economy. ASAC consists of a diverse collection of models and databases used by analysts and individuals from the public and private sectors brought together to work on issues of common interest to organizations in the aviation community. ASAC also will be a resource available to those same organizations for analyzing; informing; and assisting scientists, engineers, analysts, and program managers in their daily work. ASAC will assist through information system resources, models, and analytical expertise, and conducting and organizing large-scale studies of the aviation system and advanced technologies. Figure Chapter 1 -2 displays the concept.

*Figure Chapter 1 -2. Aviation System Analysis Capability Process*



## GOALS OF THE ASAC PROJECT: IDENTIFYING AND EVALUATING PROMISING TECHNOLOGIES

Developing credible evaluations of the economic and technological effects of advanced aviation technologies on the integrated aviation system is the principal objective of ASAC. The evaluations then will be used to help NASA program managers select the most beneficial mix of technologies for NASA investment, both in broad areas, such as propulsion or navigation systems, and in more specific projects in the broader categories. In general, engineering analyses of this kind require multidisciplinary expertise, use several models of different components and technologies, and consider multiple economic outcomes and technological alternatives. These types of analyses are most effective if they include information and inputs from organizations and analysts from different parts of the aviation community. In this way, the studies incorporate the expertise of people around the aviation community and build acceptance from the start of the research effort.

In addition to identifying broad directions for investments in technology, the program also must help researchers evaluate the economic potential of alternative technologies and systems. By better informing engineers about potential markets for technologies and data on how the current system works, ASAC will help them



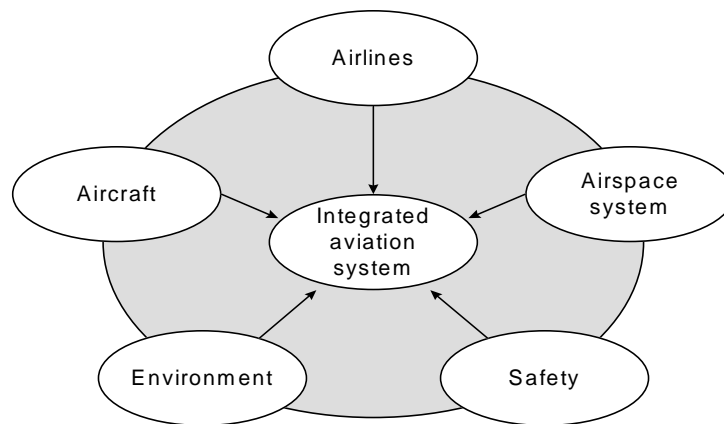
incorporate their customers' needs more easily into their routine work. These types of problems most likely involve investigating technical designs for specific aircraft or subsystems that can readily replace existing equipment without significantly changing other aviation components. With such information, researchers could more easily evaluate the utility of alternative designs and quickly estimate the value of their design concepts. Analysts from industry, government, and universities would also use ASAC in this way.

## APPROACH TO ANALYZING THE INTEGRATED AVIATION SYSTEM

The most useful aviation technologies are not necessarily the most technically advanced. Rather, the most useful technologies are those that have the most promising payoffs—those that clearly demonstrate a possibility of enhancing performance economically—from the perspective of the organizations that will purchase and operate the technologies.

Because new aviation technologies are introduced into a complex system, the potential effect of proposed technology must be analyzed from a system-wide perspective. Otherwise, the potential impact may be overestimated or underestimated because of the unexamined interdependencies with other elements of the aviation system. Figure Chapter 1 -3 shows the components of the integrated aviation system.

*Figure Chapter 1 -3. Components of the Integrated Aviation System*



In summary, by using the ASAC, users can develop credible evaluations of the economic and technological impacts of advanced aviation technologies on all components of the integrated aviation system.

---

## DOCUMENT OVERVIEW

This document describes the analyses that may be incorporated into the ASAC Executive Assistant (EA). The document will be used as a discussion tool to enable NASA and other organizations within the aviation community to evaluate, discuss, and prioritize analyses.

The document is composed of the following chapters:

Chapter 1 – Introduction

Chapter 2 – Types of Analyses and Analysis Users

Chapter 3 – Models and Data

Chapter 4 – ASAC Analyses

Chapter 5 – Summary

Chapter 2 describes the types of analyses that will be performed using ASAC, and the users who will be performing the analyses.

The next chapter presents an overview of the models and data in the ASAC repositories that will be used to perform analyses.

Chapter 4 presents the analyses that could be performed using ASAC.

Additional information on the ASAC EA is in NASA Contractor Reports #201681, *ASAC Executive Assistant Architecture Description Summary*, Eileen Roberts and James A. Villani, April 1997; #207679, *Aviation System Analysis Capability Executive Assistant Design*, Eileen Roberts and James Villani, et. al., May 1998; and a future report, *Aviation System Analysis Capability Executive Assistant Development*.

This document has a bibliography and one appendix.

## Chapter 2

# Types of Analyses and Analysis Users

---

## TYPES OF ANALYSES

Two general types of analyses will be performed using the ASAC EA. They are:

- ◆ Macro analyses that are used for high-level decision-making and resource allocation
- ◆ Bottom-up analysis, which are used for detailed decision-making, e.g., to determine if a technology is worth pursuing.

## ANALYSIS USERS

Members of the aviation community who will use the ASAC EA are:

- ◆ NASA Headquarters, who perform macro analyses
- ◆ NASA Research Centers (Ames, Langley, and Lewis), who evaluate technology and the NASA research program, and manage and conduct NASA aeronautical research programs
- ◆ FAA Headquarters, who are involved with substantial parts of NASA research, and perform for regulatory and policy analysis
- ◆ Academic researchers, including Wyle Labs, Draper Laboratory and the Massachusetts Institute of Technology, and contractors to NASA and FAA for model development and studies
- ◆ Aircraft manufacturing and air transportation industries, including Boeing, Pratt & Whitney, Lockheed Martin, air carriers; and LMI, who perform analysis and studies for all the above users.

## Chapter 3

# Models and Data

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### ASAC MODELS

Figure 3-1 diagrams the relationships between ASAC models. ASAC models are grouped into the following three analytical areas:

- ◆ 1.0 Aircraft and System Technologies
- ◆ 2.0 FAA Air Traffic Management (ATM)
- ◆ 3.0 Environment

Each model has a unique number. The number designates the model's analytical area, e.g., all model numbers that begin with "2" belong to the FAA Air Traffic Management (ATM) analytical area.

Models under development or scheduled for development contain a fiscal completion year followed by the NASA/LMI task number (if assigned).

ASAC models can be combined to form analyses. For example, an analysis might comprise the following models:

2.1 ASAC Airport Capacity Model →

2.2 ASAC Airport Delay Model →

1.5 ASAC Flight Segment Cost Model—Cost Translator →

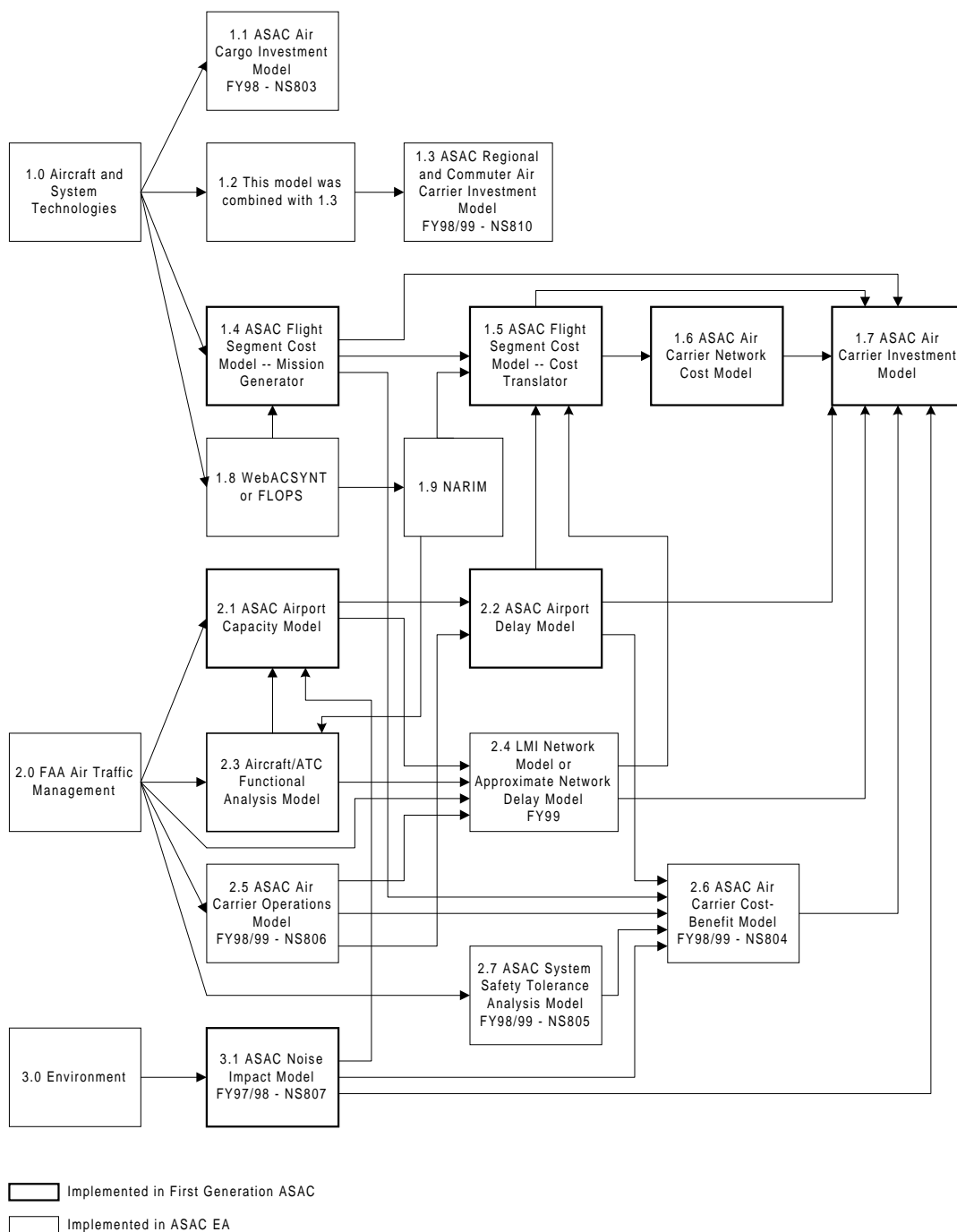
1.7 ASAC Air Carrier Investment Model.

Each of the models in Figure 3-1 is briefly described below.

- ◆ Aircraft/Air Traffic Control (ATC) Functional Analysis Model (FAM) (2.3). Evaluates communications demands and pilot and controller task loading of flights through the national airspace system.
- ◆ Aircraft Synthesis (ACSYNT) Model (1.8). Conceptual-level aircraft design and sizing model. A Web-enabled version exists (Web-ACSYNT).
- ◆ Approximate Network Delays (AND) Model (2.4). A national network model of airports.

- 
- ◆ ASAC Air Cargo Investment Model (1.1). A cargo version of the ASAC Air Carrier Investment Model (ACIM).
  - ◆ ASAC Air Carrier Cost-Benefit Model (CBM) (2.6). Estimates relative benefits of advanced aviation systems to air carrier users.
  - ◆ ASAC Air Carrier Investment Model (ACIM) (1.7). Forecasts air travel demand and airline costs.
  - ◆ ASAC Air Carrier Network Cost Model (1.6). Calculates operating cost of air carrier route structure given aircraft technology and the ATM system.
  - ◆ ASAC Air Carrier Operations Model (2.5). Forecast the future commercial air traffic service schedule based on the terminal area forecast, National Airspace System capacity, and the airline tolerance for flight delay.
  - ◆ ASAC Airport Capacity Model (ACM) (2.1). Calculates the capacity of an airport given information such as technology parameters and weather.
  - ◆ ASAC Airport Delay Model (ADM) (2.2). Calculates the delay at an airport.
  - ◆ ASAC Flight Segment Cost Model (FSCM)– Cost Translator (1.5). Calculates the cost of flying a particular aircraft from one city to another.
  - ◆ ASAC FSCM – Mission Generator (1.4). Calculates an aircraft flight trajectory based on aircraft performance, FAA regulations, and weather.
  - ◆ ASAC Noise Impact Model (NIM) (3.1). Estimates noise at an airport, calculates extra cost to an airline of flying an inefficient flight track due to noise restrictions, and evaluates the impact of preferential runway use schemes and associated ground delays.
  - ◆ ASAC Regional and Commuter Air Carrier Investment Model (1.3). A regional and commuter version of the ASAC ACIM.
  - ◆ ASAC System Safety Tolerance Analysis Model (2.7). Provides system safety modeling of advanced technologies in the terminal airspace.
  - ◆ Flight Optimization System (FLOPS) Model (1.8). Conceptual-level aircraft design and sizing model.

Figure Chapter 3 -1. ASAC Relationships



- ◆ LMINET Model (2.4). A queuing network model of the National Airspace System

- ◆ National Airspace Research and Investment Model (NARIM) (1.9).  
Simulation model of the national airspace system, plus other tools.

## ASAC DATA

Table 3-1 lists the data sources and the years of data from those sources that are in the ASAC data repositories. Each of the data sources listed in Table 3-1 is briefly described below.

*Table Chapter 3 -1. ASAC Data*

Data source	Years of data in repository
Airport Weather	1961-1997
Department of Transportation (DOT) Airline Service Quality Performance (ASQP)	1993 and 1995-1997
DOT Form 41 Financial	1989-1996
DOT Origin and Destination Matrices	1989-1996
DOT Schedule B-43 Airframe Inventory	1994-1996
DOT T-100 Flight Segment	1989-1996
DOT T-3/T-100 Airport Rank	1989-1996
FAA Aircraft Emissions	Future Requirement
FAA Noise Certification	1996
FAA Terminal Area Forecast (TAF)	1976-1996 Historical 1997-2012 Forecast
High Altitude Wind	1995-1996
International Civil Aviation Organization (ICAO) Airport Characteristics	1997
ICAO Airport Traffic	1993
Official Airlines Guide (OAG) North America and Worldwide Merge	1993
U.S. Regional Airline Fleet	1995-1996
World Jet Inventory	1993, 1995-1997

- ◆ *Airport Weather.* Contains 35 years of historical data for each of the ten Terminal Area Productivity (TAP) airports, including Department of Transportation (DOT) airport code, date, hour of day, temperature in degrees Fahrenheit, wind direction in degrees, wind speed in knots, horizontal visibility in miles, ceiling height in feet, meteorological conditions, runway conditions, and an indicator as to whether the data were observed or interpolated.
- ◆ *DOT ASQP.* Contains air carrier departure and arrival times.

- ◆ *DOT Form 41 Financial.* Data included in the Form 41 financial schedules are: balance sheet, statement of operations, transport revenues, depreciation, and amortization, aircraft operating expenses, operating expenses by objective and functional groupings, and aircraft and traffic servicing, promotion, and sales expense. Also included are Employment Statistics by Labor Category and U.S. air carrier traffic and capacity data by equipment type.
- ◆ *DOT Origin and Destination Matrices.* Contains complete passenger itinerary and related data about type of fare and dollar value of the ticket for domestic data only.
- ◆ *DOT Schedule B-43 Airframe Inventory.* Contains year of the data, DOT carrier code, DOT equipment code, ownership type (i.e., capital lease, operating lease, or owned aircraft), tail number, airframe manufacturer's serial number, year of first delivery, number of seats as specified by the air carrier, and noise category (i.e., stage 2 or stage 3).
- ◆ *DOT T-100 Flight Segment.* Contains information from each of the reporting carriers for their non-stop domestic U.S. market segments. The data elements reported by equipment type include onboard passengers, freight and mail, number of departures, segment distance, available seats, freight capacity (in pounds), block time, and airborne time.
- ◆ *DOT T-3/T-100 Airport Rank.* For their total system operations, carriers report both scheduled and non-scheduled: departures performed; enplaned passengers, tons of freight, and tons of mail. To the T-3 data are added the following summary data elements from the T-100 flight segment data: available seats, onboard passengers, tons available, block hours, and aircraft miles traveled.
- ◆ *FAA Aircraft Emissions.* Contains engine emissions test information for take-off, climbout, approach, and idle.
- ◆ *FAA Noise Certification.* Comprises approach and takeoff noise data and sideline noise data.
- ◆ *FAA Terminal Area Forecast (TAF).* Contains historical data and forecasts about 4,000 U.S. public-use airports. TAF includes airport identification code, number of runways, number of instrument landing systems, enplanement capacity, average number of days per year allowing visual flight rules operations, and observations and forecasts of aviation activity measures. Activity measures include items such as air carrier enplanements, air taxi enplanements, commuter enplanements, international enplanements, air carrier itinerant operations, air taxi itinerant operations, and general aviation itinerant operations.



- 
- ◆ *High Altitude Wind*. Contains wind data from National Oceanic and Atmospheric Administration's National Center for Environmental Prediction.
  - ◆ *ICAO Airport Characteristics*. Provides detailed assessments of individual airport infrastructure, including information about runways, taxiways, and obstacles. Also includes detailed information about proposed new runways and airports.
  - ◆ *ICAO Airport Traffic*. Tracks historical data, including movements of aircraft, passengers and freight.
  - ◆ *Official Airlines Guide (OAG) North American and Worldwide Merge*. Provides summary information about airports, carriers, equipment, and flight segments.
  - ◆ *U.S. Regional Airline Fleet*. Represents small aircraft (passenger and cargo) flown by the U.S. regional airline industry. The aircraft include both turboprop and piston engines, jets, and helicopters.

*World Jet Inventory*. Contains information on the world commercial jet airplane fleet (including some military derivatives).

## Chapter 4

# ASAC Analyses

---

This chapter describes the analyses that could be performed using ASAC. The chapter is divided into five sections. The first four sections concentrate on analyses that use ASAC models; the last section on analysis that uses ASAC data:

Analyses performed using the First Generation ASAC

- ◆ Analyses defined at the ASAC User/System Requirements Review, March 1998
- ◆ Analyses defined at the ASAC Architecture Meetings, March 1996
- ◆ Alternative and future analyses
- ◆ Requirements and analyses using ASAC Data Repositories.

Each section is divided into three categories:

- ◆ Aircraft and System Technologies
- ◆ FAA Air Traffic Management
- ◆ Environment.

Analyses are listed by category. The analysis name is followed by a depiction of the models and data used in the analysis and model links (where appropriate) represented by lines with arrows. A brief description of the analysis follows the analysis diagram.

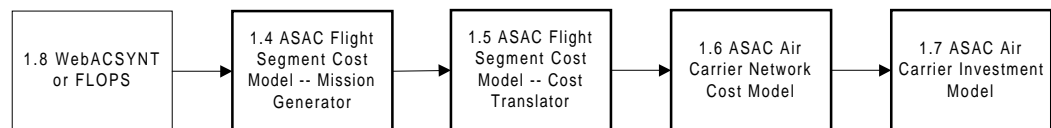
Users may simulate an analysis by running ASAC models standalone and manually transferring data between models.

---

# ANALYSES PERFORMED USING THE FIRST GENERATION ASAC

## Aircraft and System Technologies

### ANALYZE IMPROVED AIRCRAFT TECHNOLOGY



Analyze change in aircraft technology for airlines.

Inputs:

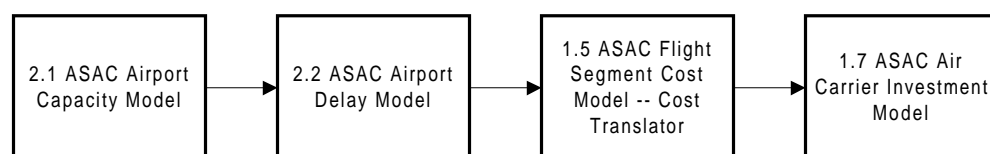
- ◆ Change in propulsion technology, e.g., engine deck, to effect:
  - an eight percent change in specific fuel consumption (SFC) for large engines
  - a 10 percent change in SFC for small engines
- ◆ Change airframe size, or
- ◆ Change in aerodynamic inputs, or
- ◆ Change in structure weight relations.

Final Outputs:

- ◆ Change in revenue passenger miles (RPM) flown
- ◆ Change in number of aircraft in fleet
- ◆ Change in employment levels.

## FAA Air Traffic Management

### ANALYZE IMPROVED AIR TRAFFIC MANAGEMENT



Analyze change in ATM for airports.

Inputs:

- ◆ Change in runway occupancy time, and/or
- ◆ Change in position uncertainty, and/or
- ◆ Change in minimum separation, and/or
- ◆ Change in approach speed uncertainty.

Final Outputs:

- ◆ Change in RPM flown
- ◆ Change in number of aircraft in fleet
- ◆ Change in employment levels.

## Environment

### ANALYZE THE EFFECTS OF AIRCRAFT NOISE REDUCTION ON COMMUNITIES

3.1 ASAC Noise  
Impact Model

Analyze the effects of aircraft noise-reduction technologies on communities.

Inputs:

- ◆ Change in study year (1993, 2005, or 2015), and/or
- ◆ Change in aircraft mixture, and/or
- ◆ Change in flight track, and/or
- ◆ Change in noise reduction by aircraft or globally, and/or
- ◆ Change in capacity and delay by usage of alternative runways.

Final Outputs:

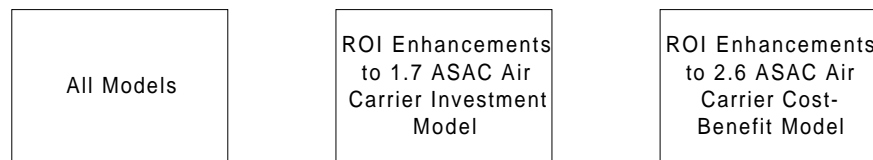
- ◆ Aircraft usage by aircraft (operations and stage length)

- 
- ◆ Aircraft usage by category (widebody, narrowbody, or propeller over long- or short-haul routes)
  - ◆ Time savings by using alternative runways
  - ◆ Time and distance savings of optimized flight tracks
  - ◆ Aggregate time and distance savings per aircraft type
  - ◆ Decibel-level noise impact on total population, total housing, total acreage, and off-airport acreage.

## ANALYSES DEFINED AT THE ASAC USER/SYSTEM REQUIREMENTS REVIEW, MARCH 1998

### Aircraft and System Technologies

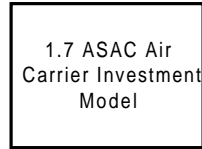
#### CROSS-PROGRAM NASA INVESTMENT/PORTFOLIO TRADES



1. Aviation Safety and Capacity Programs have existing planned budgets. A new ‘wedge’ of aeronautics funds have become available for FYxx–FYyy. Proposals have been made to create a New Millennium Aircraft Program and/or an Environment Program with the funding wedge. The existing and new programs claim quantified benefits of increased operations and throughput, delay reduction, reduced accidents, reduced operating and acquisition costs, and reduced emissions. Recommend the investment strategy for the new funding wedge that maximizes return on investment (ROI) to public citizen taxpayers, aviation manufacturing industry (all tiers), and domestic air carrier industry. Recommendation may include “No Go” for either or both new proposals and/or budget adjustments (increment or decrement) to existing programs. Repeat the analyses assuming 50/50 matching financial contributions to any or all of the programs from either or both industry groups.
2. Determine optimum balance (in terms of ROI) of NASA investment in airplane/aviation system technology driven programs versus design method/design cycle-time reduction/time-to-market-driven programs. If optimum balance cannot be calculated, compare potential ROI of design

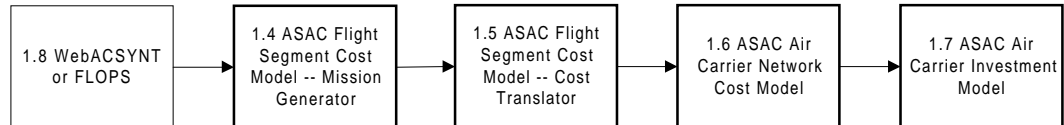
method/cycle-time/time-to-market-type program to more traditional safety, environment, and aircraft/aviation system performance technology programs.

## GLOBAL MARKET



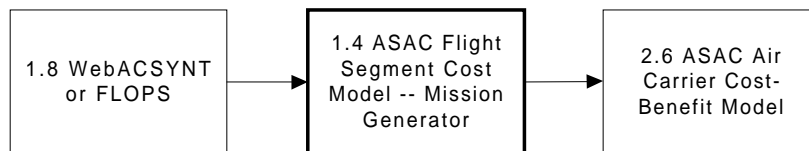
Determine the effect of current Asian economic situation on international routes, sales, rpm, air carrier (domestic and international) investment and compare to previous market projections.

## PARAMETRIC COST ESTIMATION/ECONOMETRIC COMPATIBILITY



For the operating cost methodology, ASAC uses Form 41 data to analyze overall integrated aviation system performance from top down. This provides a historical view of how the system performed in response to various market factors. However, from the standpoint of introducing new vehicles, the NASA and the air-frame/engine manufacturers analysis processes build up operating cost from the vehicle design and performance characteristics. How, if at all, do these two processes mesh within the ASAC framework?

## GO/NO-GO DECISION ON 600-PASSENGER SUBSONIC TRANSPORT

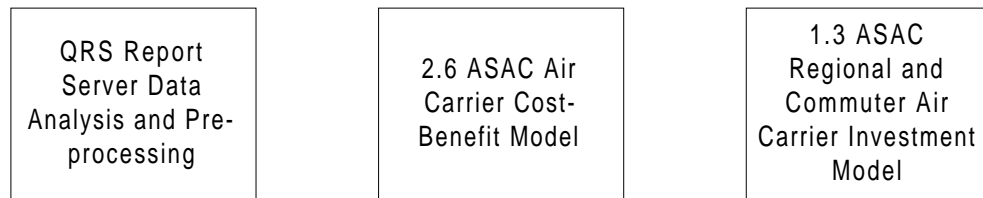


Given the current economic and RPM forecast, a major international air carrier is analyzing the potential purchase of a fleet of 600-passenger, 7500 nmi subsonic transport. Assume an average aircraft price (paid by the carrier) of \$X. Determine the potential existing routes of this carrier that could be served by the new airplane and that maximize ROI to the carrier based on estimated operating costs. For this carrier, determine the current fleet mix, including age, and operating costs of aircraft serving these routes. Determine the phase-in of the 600-passenger aircraft and phase-out of existing aircraft serving the same routes. What is the total air carrier investment, number of aircraft and price (paid by the carrier), and ROI?

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## FAA Air Traffic Management

### HUB AND SPOKE—FORECAST, DEMAND, AND IMPACT

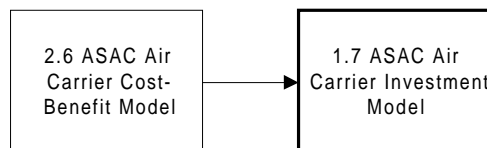


Regional and commuter air carriers are switching from turboprop to turbofan aircraft. For a given regional and commuter carrier, which operates from an airport that is also a hub of a major air carrier, these aircraft have an average range increase of X percent and an average operating cost increase of Y percent compared to its existing fleet. Determine the potential market/RPM that may be captured by the R&C from the major. Determine the minimum RPM, enplanements, or other factors required by the major for this to be a viable hub in light of the regional and commuter competition.

#### Impact of Point-to-Point Operations on Demand Curves

1. Determine the feasibility of elimination of hub and spoke in favor of point-to-point operations (calculate the benefit to taxpayers, aviation manufacturers, and air carriers).
2. Determine the potential impact to future air travel demand curves if the current hub-spoke system is eliminated in favor of point-to-point operations.
3. Determine the impact of point-to-point operations on noise and emissions (potential reduction in number of operations).
4. Determine required market demand to make point-to-point operations economically viable between a given city pair. Determine sensitivity of this analysis to increases/decreases in range and aircraft size/speed.

### COMPLETE, DETAILED ANALYSIS OF NEW TECHNOLOGY INTRODUCTION

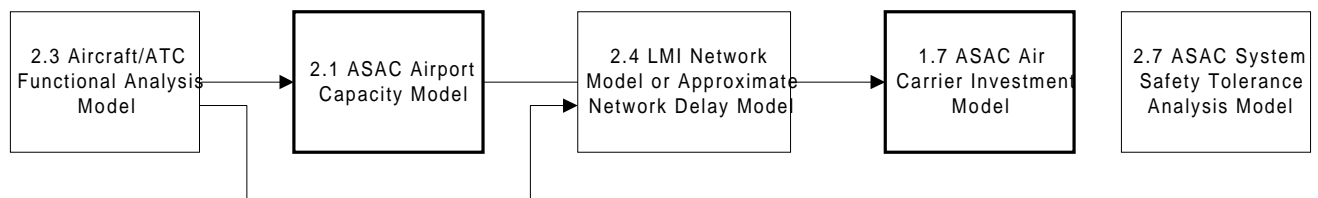


Company X approaches NASA with an idea for a new, revolutionary high-lift system for use on Boeing 737–300 airliners installed on an after-market basis. They provide estimates for the impact on the airplane weight, takeoff and landing

performance, and cost to install the new system (per airplane). Assuming that I accept their estimates, I decide to use the ASAC to analyze the impact of introducing this new technology. As input, along with the estimates provided by Company X, I also guess-timate a probable market penetration of the new technology by the year 2005 and also by 2010. What I expect from ASAC is the following:

- ◆ Cost/benefit Analysis. Using my estimate of market penetration (expressed, say, as a percentage of all 737–300 airplanes in service), how much will it cost to retrofit? What is the impact on the national economy, if any? Based on the improved takeoff and landing performance, how much fuel is saved, if any? Extrapolate that this will lead to decreased time spent on the runways—what is the aggregate effect on capacity and delay and what is the resulting financial benefit (assign a dollar amount to the reduction in delay)? How many airplanes must be retrofitted before the investment pays off (break-even point).
- ◆ Noise and Emissions Analysis (see Environment section).

#### ATM/NATIONAL AIRSPACE SYSTEM TECHNOLOGY EVALUATION

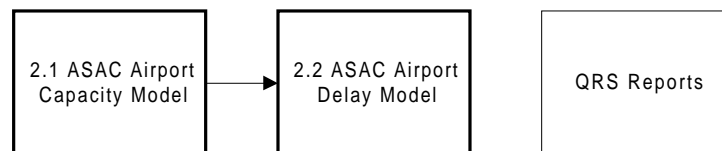


1. Determine the ability of currently planned advanced air traffic technologies to meet the predicted growth in air travel demand. If the planned technologies are incapable of meeting demand growth, determine the required performance improvement of the technologies that will satisfy the demand.
2. Evaluate potential impact/ROI of optimum departure spacing for U.S. domestic operations on throughput.
3. Determine impact/ROI of advanced navigational tools and sensors that could allow all weather operations of U.S. domestic operations.
4. Expand 2 and 3 to global operations. Note: This will not be able to be done with ASAC.
5. Given the performance requirements, reliability and operational availability of planned advanced air traffic technologies, conduct a safety assessment of the ATM/NAS with the planned new technologies relative to the current ATM/NAS assuming the same demand growth for both systems.



6. Assuming the ATM/NAS with advanced technologies is “safer” (lower probability of incident/accident/error) than the existing ATM/NAS for the same demand, what is the demand increase that the advanced ATM/NAS system can accommodate and maintain the same “safety” (probability of incident/accident/error) as the current ATM/NAS?
7. Determine the change in the margin for probability of pilot error in the advanced technology ATM/NAS relative to the current ATM/NAS for the same demand growth, i.e., more or less margin for pilot error with advanced technologies. Note: This will not be able to be done with ASAC.

## EXPAND AIRPORT CAPACITY



At most major hub airports, 25–35 percent of the operations are with regional aircraft seating 50 passengers or less. New vertical-lift technology offers the potential for separating a portion of these operations from the fixed-wing runways to VTOL sites on the airport and allowing more of the larger capacity fixed-wing aircraft to use the runways. At how many airports is this feasible? How many additional operations can be accommodated? How many of the new 40 passenger VTOL aircraft is required to meet the demand at each airport? Does this reduce delays at the hub airport

## Environment

### COMPLETE, DETAILED ANALYSIS OF NEW TECHNOLOGY INTRODUCTION



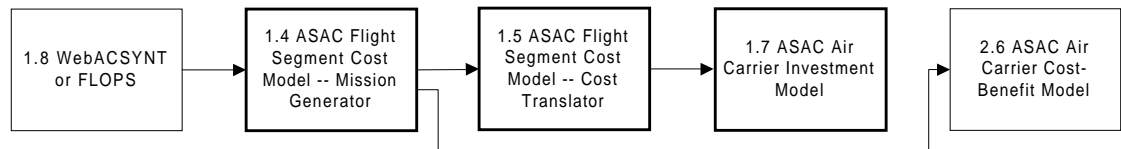
#### ◆ Noise and Emissions Analysis

Retrofitted airplanes will not take as long to reach cruise altitude and will have shorter descent profiles. Provide a quantitative measure of how the noise will be reduced. Similarly, since both climb and descent phases of flight have higher rates of fuel consumption than cruise and now that these phases will be shortened, what is the quantitative effect on emissions?

## ANALYSES DEFINED AT THE ASAC ARCHITECTURE MEETINGS, MARCH 1996

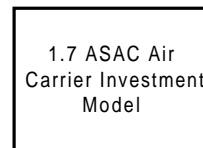
### Aircraft and System Technologies

#### AIRCRAFT TECHNOLOGY AND AVIATION INDUSTRY SYSTEM



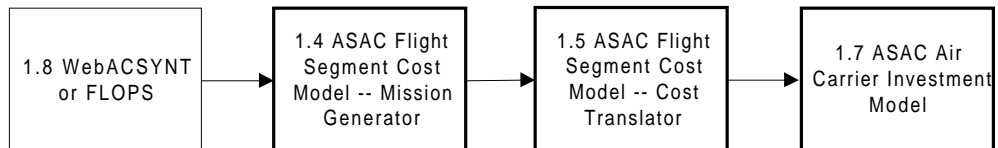
Build a detailed cost-benefit model to analyze the viability of advanced aircraft technologies.

#### IMPACT ON THE U.S. ECONOMY, EMPLOYMENT, AND TRADE



Quantify the impact of various technologies on the U.S. economy, employment, and trade.

#### AIRCRAFT TECHNOLOGY AND AVIATION INDUSTRY



Translate aircraft technology concepts into aircraft physical performance measures, such as speed, fuel burn, payload, range, and airfield accessibility.

Estimate development and production costs for new aircraft (including airframes, propulsion, and avionics) and substantial modifications to existing aircraft and aircraft components, from preliminary aircraft design information.

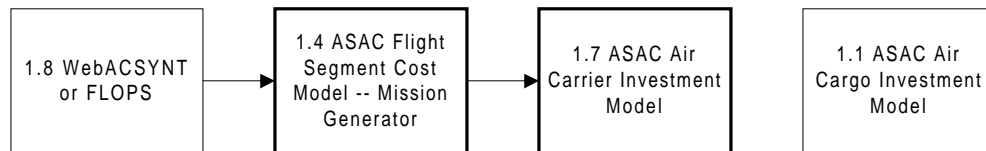
Estimate operating costs for new and existing aircraft as a function of utilization.

Estimate the economic viability of advanced aircraft designs, through quantitative technical and business performance comparisons of conceptual designs with existing aircraft or other possible alternatives.

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Evaluate design or operational constraints.

## AIR CARRIER INVESTMENTS



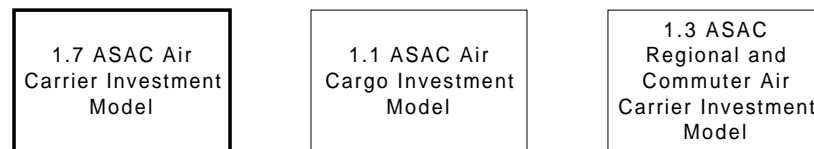
Estimate air carrier industry cost, revenue, and profit functions.

Estimate air carrier investments as a function of aircraft characteristics, aircraft acquisition and operating costs, and air traffic performance.

Estimate long-run world-wide demand for passenger and cargo transportation services, as a function of demographics, economic variables.

Provide long-run forecasts of aircraft purchases.

## AGGREGATE ECONOMIC IMPACTS



Estimate impact on the U.S. economy of the introduction of new technology and other changes in the air transportation sector, based on the aviation industry analysis results.

Calculate the feedback effect of general economic conditions on the aviation-related industries.

Estimate the non-U.S. impact of new technologies (international sales and market share).

Evaluate the potential implications of regulatory changes in other countries on the sales and services of U.S. airlines and manufacturers.

## UNDERLYING DEMAND FOR AIR TRAVEL

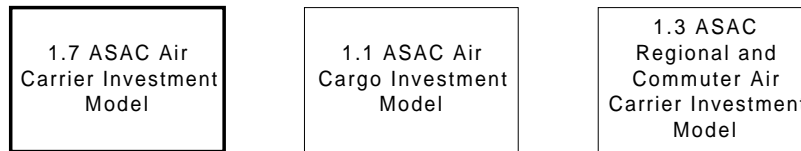


What is the underlying world-wide demand for air travel? Need origin and destination data for passengers, revenues, itinerary miles, and average coupons.

What are the airlines' revenues generated by this air travel? Need average fare per revenue passenger mile, and revenue passenger miles flown.

What are the forecasted levels of passenger and freight traffic on global, regional, and U.S. national bases? Need revenue passenger miles and revenue ton miles.

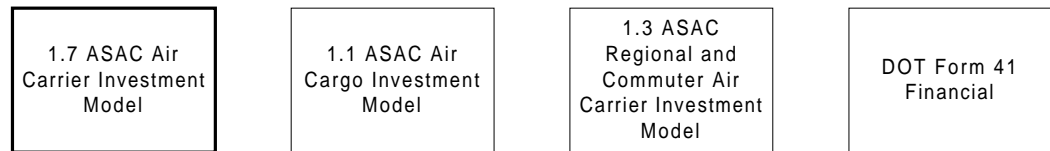
## ECONOMIC VALUE OF AIRLINE INDUSTRY



How important is the air transportation industry to the U.S. economy in terms of economic activity generated? Need industry revenues, gross domestic product, employment.

Which industries are the primary suppliers to the air transportation industry? Ranked by industry sales and value added.

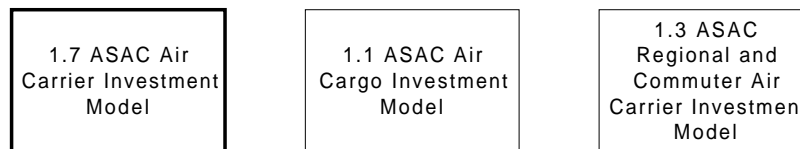
## ECONOMIC VALUE OF AIRCRAFT AND AIRCRAFT SYSTEMS MANUFACTURING



How important are the aircraft and aircraft systems manufacturing industries to the U.S. economy in terms of economic activity generated? Need industry revenues, gross domestic product, and employment.

Which industries are the primary suppliers to the aircraft and aircraft systems manufacturing industries? Ranked by industry sales and value added.

## AIRLINE OPERATIONS ANALYSIS AND INVESTMENT MODELING



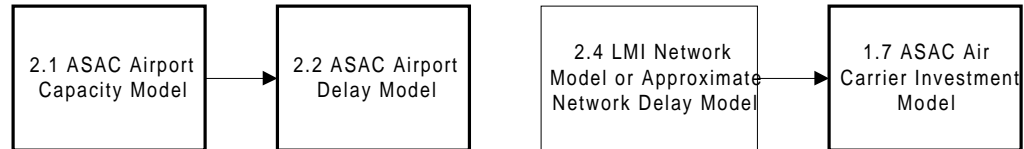
Build a model to generate forecasts of air travel demand, airline costs, and required aircraft inventories.

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Build a second model that estimates the cost to operate a representative (or actual) airline route structure with different aircraft.

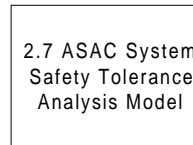
## FAA Air Traffic Management

### AIRSPACE INFORMATION AND MODELING



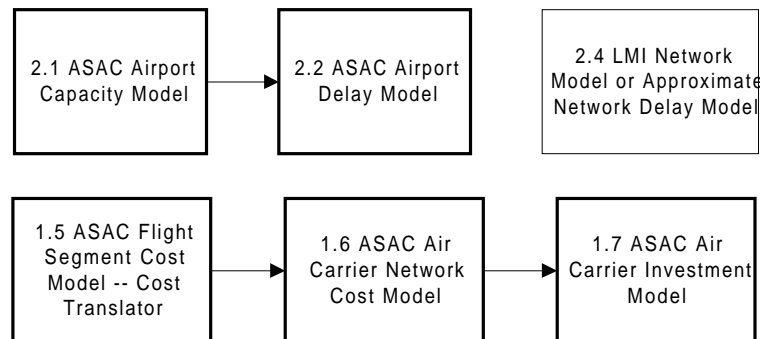
Build tools to analyze the potential impact of airspace technologies and new aircraft.

### DEVELOP SYSTEM SAFETY INFORMATION AND MEASURES



Develop a model to estimate system safety tolerance.

### AIRSPACE

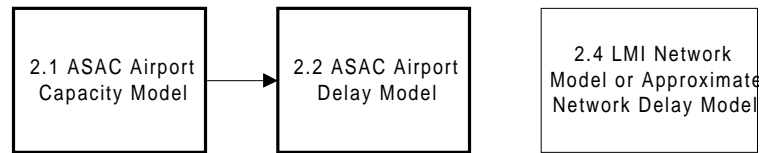


Translate Air Traffic Control (ATC) technology concepts and investments into system performance parameters.

Estimate air transportation system performance changes due to the introduction of advanced technologies, with performance measured by total travel time, delay time, and total system operating costs.

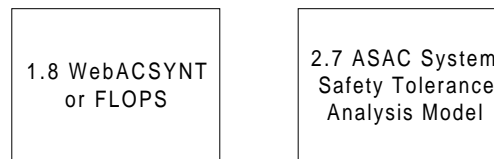
Evaluate the impact of improved ATC performance on passenger and cargo services.

## AIR CARRIER OPERATIONS



Evaluate changes in procedures to maximize existing technology compared to stasis in procedures coupled with new technology.

## SAFETY



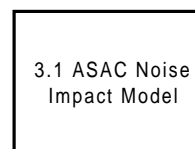
Predict safety impacts of advanced aircraft designs based on current and proposed regulations.

Evaluate the impact of safety regulations on the cost, quantity, and quality of air transportation services.

Develop methodologies for evaluating the safety of the air transportation system from the overall system viewpoint.

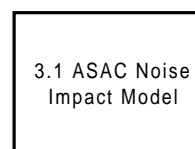
## Environment

### METHODS TO ASSESS ENVIRONMENTAL IMPACTS



Estimate the noise characteristics of new aircraft and evaluate the noise impacts of aircraft operations on airport areas.

### ENVIRONMENTAL IMPACTS: NOISE



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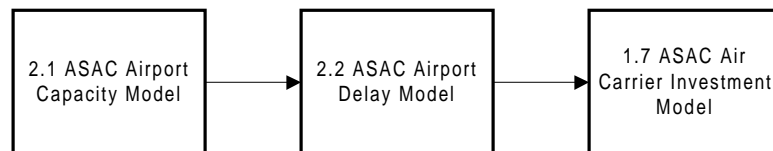
Integrate noise exposure models and demographic databases for use in estimating community noise impact.

Analyze noise effects at selected airports resulting from advanced designs and aircraft modifications.

Quantify the impact of local noise restrictions on airline operations and the overall level and quality of air transportation services provided.

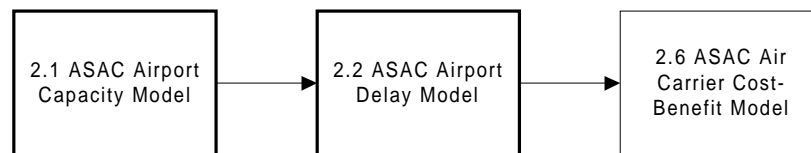
## ALTERNATIVE AND FUTURE ANALYSES

### Functional Analysis (Alternative to Econometric Analysis)



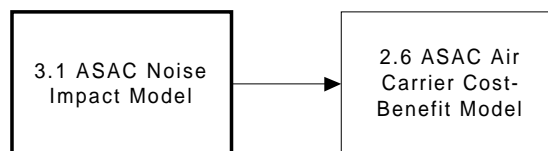
Alternative to econometric analyses using the ASAC FSCM—Cost Translator.

### Future Analysis 1



TBD

### Future Analysis 2



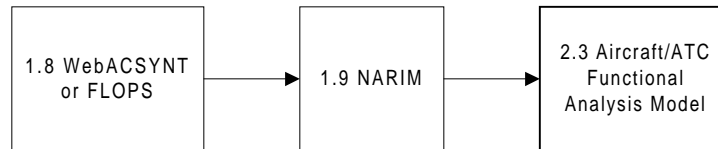
TBD

### Future Analysis 3



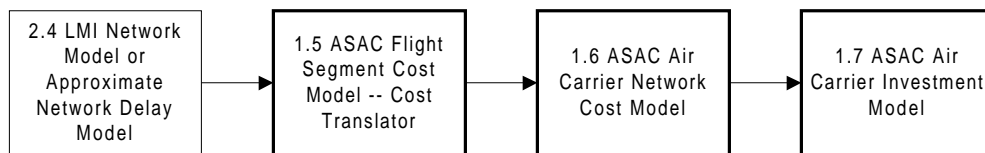
TBD

## Future Analysis 4



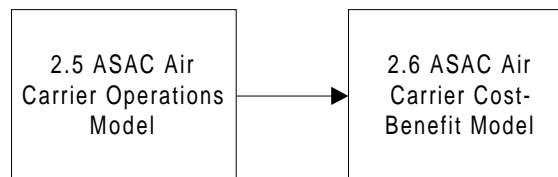
TBD

## Future Analysis 5



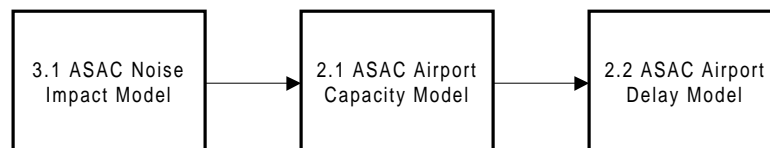
TBD

## Future Analysis 6



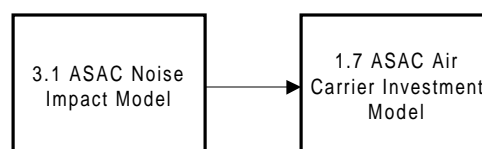
TBD

## Future Analysis 7



TBD

## Future Analysis 8

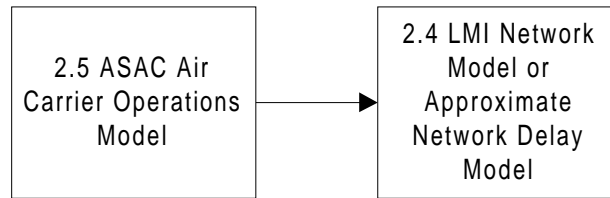




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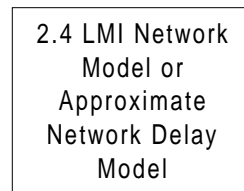
TBD

## Future Analysis 9



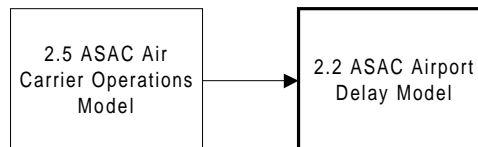
TBD

## Future Analysis 10



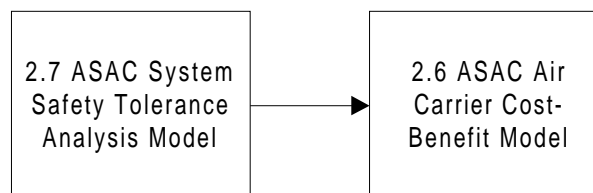
TBD

## Future Analysis 11



TBD

## Future Analysis 12

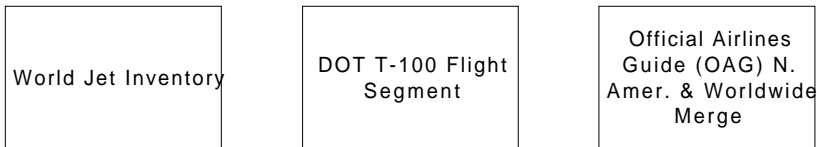


Evaluate the costs and benefits of safety improvements.

## REQUIREMENTS AND ANALYSES USING ASAC DATA REPOSITORIES

### Aircraft and System Technologies

#### AIR CARRIER INVESTMENTS



Provide current airframe and engine inventory data, linked to utilization data on flights by aircraft type and city pair.

### FAA Air Traffic Management

#### AIRSPACE INFORMATION AND MODELING



Construct databases describing air traffic and airport operations and capacity.  
Note: ASAC does not provide capacity data.

#### DEVELOP SYSTEM SAFETY INFORMATION AND MEASURES



Provide access to searchable databases of aviation incidents and accidents.

#### AIRSPACE

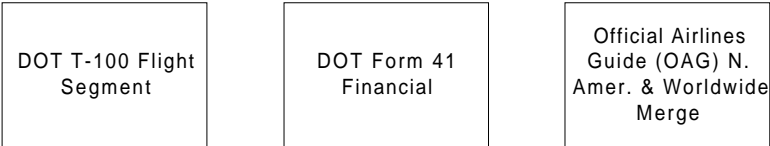


Provide representative flight schedules for use in analyzing the impact of new aircraft and ATM technologies on air transportation system performance.

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Provide databases of airport capacity, and historic and forecasted operations by airport. Note: ASAC does not provide capacity data.

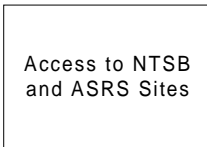
AIR CARRIER OPERATIONS



Provide up-to-date (recent) estimates for air carrier flight segment and cost information to serve as a baseline comparison for evaluating new technologies, and changes in carrier operational strategies.

Provide representative flight schedules for use in forecasting the use and impact of new aircraft and procedures by airlines.

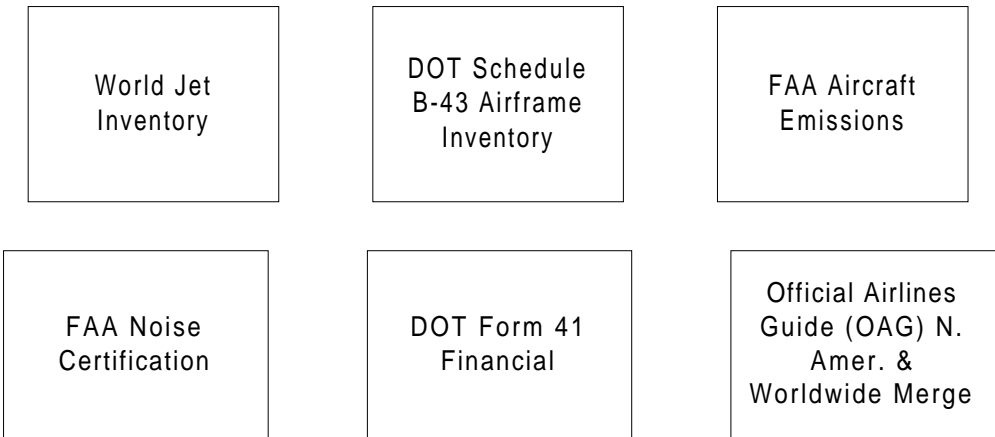
SAFETY



Provide access to current aviation accident/incident databases.

Environment

AIRCRAFT FLEETS



What is the composition of the current transport aircraft fleet? Quantity by type of equipment, engine type and model installed on aircraft.

Which countries and firms own and operate these aircraft? Need country and company.

How old are the aircraft? Need dates of order, delivery, and sale, lease, or loss by accident.

What noise stage are they? Need typical noise stage by equipment and engine combination.

What level of emissions do they create? Need emissions per idle, takeoff, climbout, and approach by type of engine.

How is a specific type of equipment typically used? Need annual usage in terms of block hours operated, number of trips, and aircraft miles flown; average duration of flights in terms of block time and stage length.

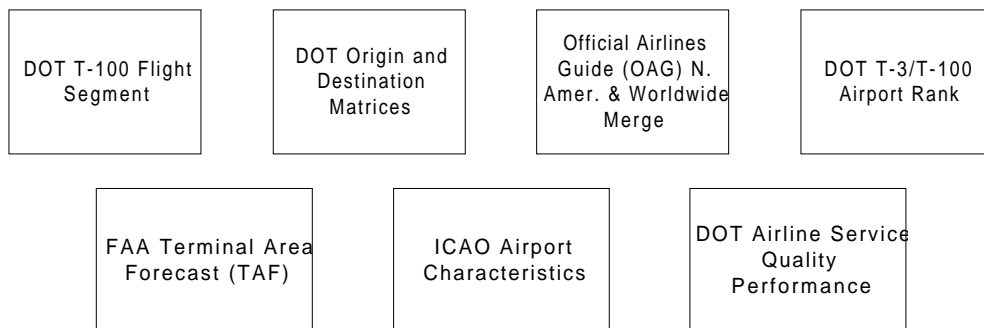
What are the operating costs? Need operating cost per: year, typical flight, block hour, aircraft mile, and available seat miles.

#### UNDERLYING DEMAND FOR AIR TRAVEL



What are the highest density city pairs? Need passengers per day, revenue passenger miles, and aggregate revenues for the top 100 domestic and international city pairs.

#### AIR TRAFFIC



What are the current patterns of air traffic (i.e., how do the airlines satisfy the underlying world-wide demand for air travel through their decisions about routing) for domestic only? Need point-to-point flights versus hubbing operations.

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What are the current patterns of air traffic (i.e., how do the airlines satisfy the underlying world-wide demand for air travel through their decisions about equipment usage)? Need type of equipment used on each flight segment.

What are the current patterns of air traffic (i.e., how do the airlines satisfy the underlying world-wide demand for air travel through their decisions about frequency of flights)? Need number of flights per day, week, and year.

What are the block times for these flights? Need average block time per flight segment.

Which airports are the busiest? Ranked by number of aircraft departures and enplaned passengers.

What are the capacities of U.S. and foreign airports? How do airport usage rates compare with airport capacities (which airports are the most critically constrained by their current capacities)? Need number of runways, instrument landing systems, practical annual capacity, and visual flight rule days per year.

What are the current levels of aircraft and passenger delay by airport and cause of delay? Need delay by cause (weather, terminal volume, center volume, closed runway or taxiway, or NAS equipment interruptions) and by phase of flight (gate-hold, taxi-out, airborne, or taxi-in).

## ECONOMIC VALUE OF AIRLINE INDUSTRY

DOT Form 41  
Financial

What are the largest firms in terms of output, revenues, and employment? How healthy are they in terms of operating incomes, balance sheets, and debt ratings? Ranked by sales, profits, assets, and financial health.

## Chapter 5

# Summary

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Forty analyses were defined using ASAC models in three functional areas: Aircraft and System Technologies, FAA Air Traffic Management, and Environment. These analyses will be prioritized and added to the ASAC Executive Assistant as permitted by resources. An additional ten analyses and requirements were defined using ASAC data repositories. All the above mentioned analyses are summarized in Table 5-1.

*Table Chapter 5 -1. ASAC Analyses*

ANALYSES USING ASAC MODELS															
	FAM	ACSynt	AND	ACargoIM	C-B	ACIM	NCM	ACOM	ACM	ADM	FSCM-CT	FSCM-MG	NIM	RACIM	Safety
Analyses performed using FGA															
Aircraft and System Technologies															
Analyze Improved Aircraft Technology		X				X	X				X	X			
FAA Air Traffic Management															
Analyze Improved Air Traffic Management						X			X	X	X				
Environment															
Analyze the Effects of Aircraft Noise Reduction														X	
Analyses defined in March 1998															
Aircraft and System Technologies															
Cross-Program NASA Investment/Portfolio Trades	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Global Market						X									
Parametric Cost Estimation/Econometric Comp.		X				X	X				X	X			
Go/No Go on 600 Passenger Subsonic Transport		X			X							X			
FAA Air Traffic Management															
Hub and Spoke -- Forecast, Demand, and Impact					X	X								X	
Complete, Detailed Analysis of New Technology Intro.					X	X									
ATM/NAS Technology Evaluation	X		X			X			X						X
Expand Airport Capacity									X	X					
Environment															
Complete, Detailed Analysis of New Technology Intro.													X	X	
Analyses defined in March 1996															
Aircraft and System Technologies															
Aircraft Technology & Aviation Industry System		X			X	X					X	X			
Impact on the U.S. Economy, Employment and Trade						X									
Aircraft Technology and Aviation Industry		X				X					X	X			
Air Carrier Investments		X		X		X						X			
Aggregate Economic Impacts				X		X									
Underlying Demand for Air Travel				X		X									X
Economic Value of Airline Industry				X		X									X
Economic Value of Aircraft and Aircraft Systems Mfg.				X		X									X
Airline Operations Analysis and Investment Modeling				X		X									X
FAA Air Traffic Management															
Airspace Information and Modeling			X			X			X	X					
Develop System Safety Information and Measures															
Airspace			X			X	X		X	X	X				X
Air Carrier Operations			X						X	X					
Safety		X													X
Environment															
Methods to Assess Environmental Impacts														X	
Environmental Impacts: Noise														X	
Alternative and Future Analyses															
Functional Analysis						X			X	X					
Future Analysis 1					X				X	X					
Future Analysis 2					X									X	
Future Analysis 3		X													
Future Analysis 4	X	X										X			
Future Analysis 5			X			X	X				X				
Future Analysis 6					X										
Future Analysis 7									X	X				X	
Future Analysis 8						X								X	
Future Analysis 9			X						X						
Future Analysis 10															
Future Analysis 11								X		X					
Future Analysis 12					X										X
REQUIREMENTS AND ANALYSES USING ASAC DATA REPOSITORIES															
	Weather	ASQP	Form 41	O&D	B-43	T-100	T-3/T-100	Noise Cert	Emissions	TAF	Wind	Region Air	OAG	World Jet	ICAO AC
Aircraft and System Technologies															
Air Carrier Investments						X							X	X	
FAA Air Traffic Management															
Airspace Information and Modeling						X	X						X		
Develop System Safety Information and Measures															
Airspace										X			X		
Air Carrier Operations			X			X							X		
Safety															
Environment															
Aircraft Fleets			X		X			X	X				X	X	
Underlying Demand for Air Travel						X							X		
Air Traffic		X			X	X	X			X			X		x
Economic Value of Airline Industry			X												

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Roberts, Eileen and James A. Villani. "ASAC Executive Assistant Architecture Description Summary," National Aeronautics and Space Administration Contractor Report #201681, April 1997.

Roberts, Eileen. "Proceedings of the Aviation System Analysis Capability Architecture Meetings, 11 - 20 March 1996," LMI informal deliverable, May 1996.



# Appendix A

## Abbreviations

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ACIM	Air Carrier Investment Model
ACM	Airport Capacity Model
ACSYNT	Aircraft Synthesis model
ADM	Airport Delay Model
AND	Approximate Network Delay model
ASAC	Aviation System Analysis Capability
ASQP	Airline Service Quality Performance
AST	Advanced Subsonic Technology
ATC	Air Traffic Control
ATM	Air Traffic Management
DOT	Department of Transportation
EA	Executive Assistant
FAA	Federal Aviation Administration
FAM	Functional Analysis Model
FLOPS	Flight Optimization System model
ICAO	International Civil Aviation Organization
NARIM	National Airspace Research and Investment Model
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NIM	Noise Impact Model
OAG	Official Airlines Guide
ROI	return on investment
RPM	revenue passenger miles
SFC	specific fuel consumption
TAF	Terminal Area Forecast
VTOL	vertical takeoff and landing

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
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